

REVIEW

The Origin of Japanese Dogs and their Association with Japanese People

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Short History of Domestication of Animals with Emphasis on Dogs

Most relationships between man and the domesticated animals are commensalism, meaning a close association or union between two species of organisms, in which one is benefitted by the relationship and the other is neither benefitted nor harmed, but it is not a partnership, meaning that in which both are mutually benefitted, except in two cases: that of the dog and the cat (see for reviews: Mason [1] and Tanabe [2]).

Dogs (*Canis familiaris*) are the oldest domesticated animal in the preagricultural age, and were domesticated between 14,000 and 12,000 before present (BP) [3]. However, the earliest archaeologically dated (ca. 35,000-38,000 BP) evidence for the presence of domesticated dogs comes from the Douara Cave near Palmyra in Syria [4]. Dogs are believed to have derived solely from wolves (*Canis lupus*) [5, 6, 7].

Man also domesticated reindeers (*Rangifer tarandus*) in the early preagricultural age (15,000 BP), and sheep (*Ovis aries*), goats (*Capra hircus*), pigs (*Sus domesticus*) shortly before the preagricultural age. Cattle (*Bos taurus*) and chickens (*Gallus gallus domestica*) were domesticated shortly after the start of agronomic agriculture (ca. 10,000 BP) [1, 2].

Pigeons (*Columba livia*), camels (*Camelus bactrianus*, *Camelus dromedarius*), lamas (*Lama glama*), alpacas (*Lama pacos*), buffaloes (*Bubalus bubalus*), honey bees (*Apis mellifera*, *Apis cerana*), silk worm moths (*Bombix mori*), Asian elephants (*Elephas maximus*), cats (*Felis catus*), guinea pigs (*Cavia porcellus*), geese (*Anser domesticus*), ducks (*Anas platyrhynchos*), muscovy ducks (*Cairina moschata*), turkeys (*Meleagris gallopavo*), guinea fowls (*Numida meleagris*) and yaks (*Bos grunniens*) were domesticated in the prehistorical and early historical periods after the establishment of agriculture. Most of them were domesticated in the Old World, except lamas, alpacas, guinea pigs, muscovy ducks and turkeys, which were domesticated in the New World [1, 2].

Mice (*Mus musculus*) and Norway rats (*Rattus norvegicus*) encountered man in the early agricultural age, and have been parasite animals for a long time. However, a large number of them have been domesticated and have been used as experimental animals in biology and medicine [2].

In the historical age, a few wild animals were domesticated; i.e. rabbits (*Oryctolagus cuniculus*) for meat production in France, Japanese quail (*Coturnix coturnix japonica*) for egg production in Japan, minks (*Mustela vison*) and foxes (*Vulpes vulpes*) for fur production in U.S.A., Canada and USSR [1, 2].

Interestingly, a few animals had been domesticated and became commensalism animal, but have been abandoned by man later. Two of examples of them are African elephants (*Loxodonta africanus*) and cheetas (*Acinonyx jubatus*) [1, 2].

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Although man has regarded animals around him as a source of food and raw materials, the domestication of the dog continued an exception, as man and dog joined to form a hunting team in the preagricultural age. In this sense, the relationship man and dog can be called partnership but not commensalism which is commonly observed between man and other domesticated animals [8].

Dogs always migrated with man since the ancient ages. The evidence suggests that it is possible to trace the route of migration of man by tracing the route of dog populations in the prehistoric ages.

Blood Protein Polymorphisms of Dogs

Findings of polymorphisms in blood proteins including enzymes (isozymes) in various domesticated animals have enabled us to elucidate the genetic relationships of the breeds or populations of the animals.

Blood samples were taken by us from the foreleg vein of 3,632 individual dogs including (a) 20 Eskimo dogs (pedigreed); (b) one Korean native

breed (pedigreed): 229 Jindo dogs, and one Korean local population: 125 Chejudo dogs; (c) ten Japanese native breeds or varieties (pedigreed): 119 Hokkaido, 240 Akita, 108 Kai, 81 Kishu, 90 Shikoku, 70 Akita Shiba, 206 Shinshu Shiba, 113 Mino Shiba, 65 San'in Shiba and Ryukyu (103 Yanbaru, and 30 Ishigaki) dogs, and eight Japanese local populations: Mie hunting dogs (30 in Shima and 19 in Nanto), 83 Tsushima, 40 Iki, 45 Tanegashima, 38 Yakushima, 92 Amamioshima, 71 Okinawahonto and 20 Iriomotejima; (d) 144 Taiwan native dogs and three Chinese origin breeds (pedigreed): 20 Chin, 10 Chow Chow and 18 Pug; (e) 15 European breeds (pedigreed): 33 Shetland Sheepdogs, 73 Malteses, 16 Poodles, 22 Collies, 64 Pointers, 26 Boxers, 28 Yorkshire Terriers, 74 German Shepherds, 19 English Setters, 20 Cooker Spaniels, 27 Pomeranians, 14 Dalmatians, 20 Doberman Pinschers, 18 Dachshunds and 412 Beagles; (f) 3 Russian breeds (pedigreed): 34 Laikas, 27 Middle Asian Sheepdogs and 27 Caucasian Sheepdogs; (g) 60 Bangladesh native dogs.

Blood was centrifuged at 3,000 rpm for 10 min.

TABLE 1. Genetic variations in the 16 blood proteins or enzymes, and the mode of inheritance.

proteins or enzyme	Locus	Allele	Reference
<i>Protein</i>			
Plasma albumin	(Alb)	$Alb^F = Alb^S$	[12]
Plasma postalbumin	(Poa)	$Poa^A = Poa^B = Poa^C$	[13]
Plasma postalbumin-3	(Poa-3)	$Poa-3^A = Poa-3^B$	[14]
Plasma prealbumin-1	(Pa-1)	$Pa-1^A = Pa-1^B$	[14]
Plasma transferrin	(Tf)	$Tf^A = Tf^B = Tf^C = Tf^D = Tf^E$	[12, 15]
Plasma pretransferrin	(Ptf)	$Ptf^A > Ptf^O$	[16]
Erythrocyte hemoglobin	(Hb)	$Hb^A = Hb^B$	[17]
<i>Enzyme</i>			
Plasma alkaline phosphatase	(Akp)	$Akp^A = Akp^B = Akp^C$	[13]
Plasma esterase resistant esterase	(Es)	$Es^A = Es^B = Es^C$	[18]
Plasma leucine aminopeptidase	(Lap)	$Lap^A = Lap^B$	[19]
Erythrocyte acid phosphatase	(Pac)	$Pac^F = Pac^S$	[19]
Erythrocyte esterase-2	(Es-2)	$Es-2^S > Es-2^F$	[13]
Erythrocyte esterase-3	(Es-3)	$Es-3^A = Es-3^B$	[13]
Erythrocyte glucose phosphate isomerase	(GPI)	$GPI^A = GPI^B$	[21]
Erythrocyte tetrazolium oxydase	(To)	$To^A = To^B$	[22]
Erythrocyte ganglioside monooxygenase	(Gmo)	$Gmo^S > Gmo^a$	[11]

A=B indicates that A and B are codominant alleles.

A>B indicates that A is a dominant allele and B is a recessive one.

The erythrocyte fraction was washed twice with isotonic saline. The plasma and cell fractions were stored separately at -80°C until use. Horizontal starch gel electrophoresis for enzymatic proteins [9], horizontal polyacrylamide gradient gel electrophoresis for non-enzymatic proteins [10], and thin layer chromatography for ganglioside monoxygenase [11] were used to detect electrophoretic and biochemical variations of proteins in plasma and erythrocytes.

Genetic variations were observed in six loci composed of seven non-enzymatic proteins: plasma albumin (*Alb*), plasma postalbumin (*Poa*), plasma postalbumin-3 (*Poa-3*), plasma prealbumin-1 (*Pa-1*), plasma transferrin (*Tf*), plasma pretransferrin (*Ptf*) and hemoglobin (*Hb*), and nine enzymatic proteins: plasma alkaline phosphatase (*Akp*), plasma eserine resistant esterase (*Es*), plasma leucine aminopeptidase (*Lap*), erythrocyte acid phosphatase (*Pac*), erythrocyte esterase-2 (*Es-2*), erythrocyte esterase-3 (*Es-3*), erythrocyte glucose phosphate isomerase (*GPI*), erythrocyte tetrazolium oxidase (*To*) and ganglioside monoxygenase (*Gmo*). On the other hand, no genetic variations were found at 11 loci controlling three non-enzymatic proteins: plasma postalbumin-2 (*Poa-2*), plasma prealbumin-2 (*Pa-2*) and plasma slow- α_2 macroglobulin (α_2) and eight enzymatic proteins: plasma amylase (*Amy*), plasma esterase-fast (*Es-f*), erythrocyte adenylate kinase (*Ak*), erythrocyte esterase-fast (*Cell-Es-f*), erythrocyte glucose-6-phosphate dehydrogenase (*G-6-PD*), erythrocyte lactate dehydrogenase-A and -B (*LDH-A* and *LDH-B*) and erythrocyte leucine aminopeptidase (*Cell-Lap*). The mode of inheritance of all the polymorphisms loci are given in TABLE 1.

Description of Native Dog Breeds and Populations in Japan and Its Adjacent Areas

In Japan, there are 11 indigenous dog breeds or varieties (pedigreed) [23, 24]: the Hokkaido dog is a medium-sized breed, body height being 40–55 cm, originating from Hokkaido Island, and used to be called the Ainu dog because it was kept by Ainu. The Akita dog is a large-sized breed, body height being 58–70 cm, originating from Akita

Prefecture. The Kai dog is a medium-sized breed, body height being 40–50 cm, originating from Yamanashi Prefecture, and characterized by the brindle coat color. The Kishu dog is a medium-sized breed, body height being 46–55 cm, originating from Wakayama Prefecture. The Shiba dog is a small-sized breed, body height being 35–41 cm, and consisting four local varieties, i.e. Shinshu originating from Nagano Prefecture and a major variety spreading all over Japan; San'in is a minor one living in Tottori and Shimane Prefectures, Mino is a minor one, living in Gifu Prefecture, and Akita originaing mainly eastern parts of Japan and belonging to Shiba-Inu Preservation Association at Omagari in Akita Prefecture, and characterized by the very shallow-stopped face. The Shikoku is a medium-sized breed, body height being 46–52 cm, originating Kochi Prefecture in Shikoku Island. The Ryukyu dog is a medium-sized breeds, originating from Nago-shi and Yanbaru district in northern Okinawahonto and a similar one is in Ishigaki Island, and both are characterized by the brindle coat color. There are eight local populations of indogenous dogs in Japan. Five of them are living in the Ryukyu or Nansei Islands: Tanegashima, Yakushima, Amamioshima, Okinawahonto (middle and southern regions) and Iriomotejima. Two of them are living in the two islands existing between Japan and Korea: Iki and Tsushima. The final two are living in the Shima peninsula and Nanto-machi in the south-east coast of the Kishu peninsula, and are called Mie hunting dogs (Shima and Nanto).

There are four indigenous dog populations in the mountain area of Taiwan [25]: Atyl (north), Bunun (middle), Rukai (south) and Ami (east). The dogs were named after the names of tribes living in the area. Data from these dog populations were combined, because the genetic differences among the populations were small.

The Jindo dog is a medium-sized breed, and is the only one registered as a Korean native breed, originating from Jindo Island. We took blood samples from 210 pedigreed dogs on Jindo Island and 19 pedigreed ones in Seoul [25]. there are indigenous dog populations in Chejudo Island [25]. We took blood samples of Eskimo dogs (pedigreed) in Obihiro Zoo and adjacent areas,

and also from the indigenous dogs in Bangladesh [26, 27].

The blood samples from three Chinese origin dog breeds (the Chow Chow, the Chin and the Pug; all pedigreed), and 15 European dog breeds (pedigreed) were collected from various institutions, Universities and veterinary hospitals in Gifu, Nagoya and Tokyo in Japan. The blood samples of three Russian dog breeds (pedigreed) were collected in Novosibirsk, USSR.

Genetic Relationships of Dogs with Emphasis on Asian and Japanese Dogs

The genetic relationships among the dog breeds, with special reference to Asian dog breeds including Japanese dog breeds, were studied by biochemical polymorphisms of the blood detected by electrophoretic and chemical analyses. The intention was elucidate the origin of Japanese native dogs with an emphasis on their migration routes

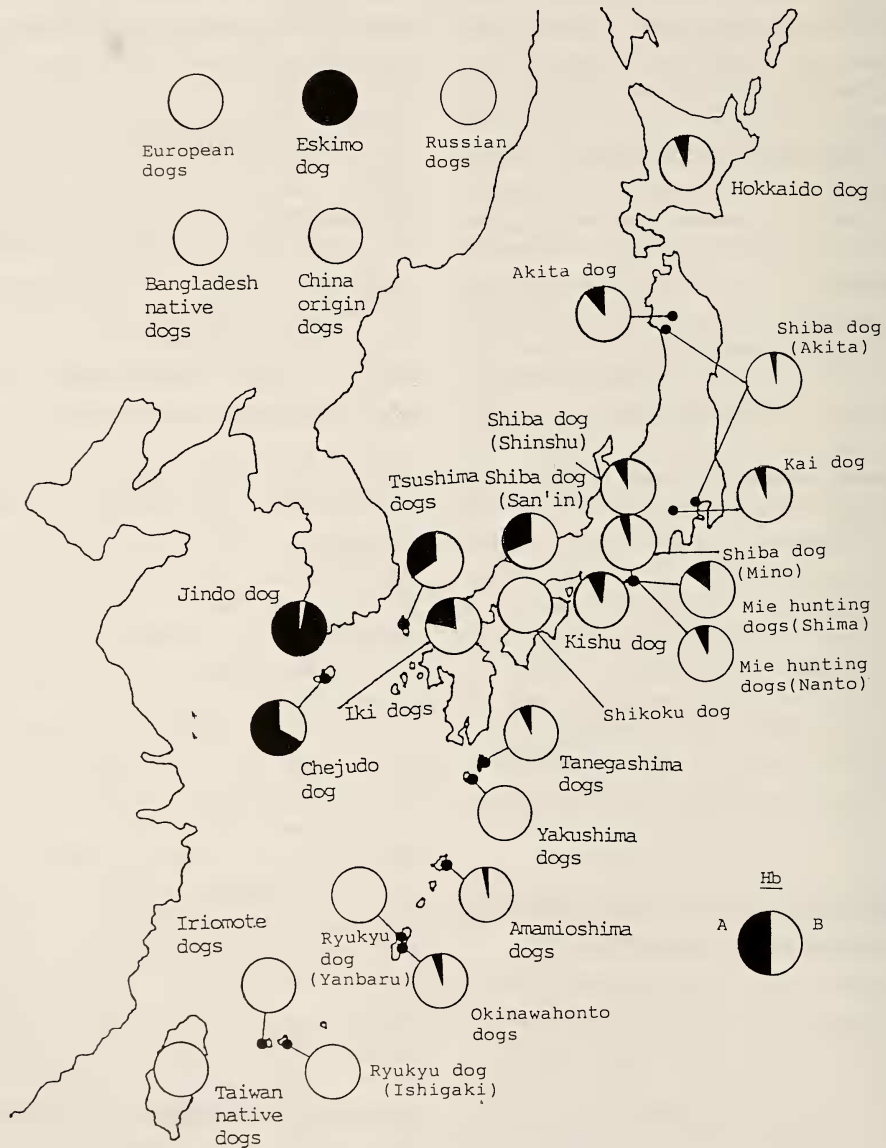


FIG. 1. Geographical distribution of dog erythrocyte hemoglobin (Hb) variants in Japan and its adjacent areas.

and their association with Japanese people [12,14, 24, 28, 29].

The most prominent differences of gene frequency among the dog breeds or populations were observed in *Hb* and *Gmo* variations. *Hb^A* was found only in Asian breeds or populations, but not in European breeds and Russian breeds. Distribution of *Hb* alleles among the Asian dog breeds or populations is shown in Figure 1. The data clearly show the gene flow of *Hb^A* from the Korean

peninsula into the Japanese Islands. A similar tendency was found in the genes of *Gmo*. *Gmo^S* was also found only in Asian breeds or populations, but not in European breeds and Russian breeds. Distribution of *Gmo* alleles among the Asian dog breeds or populations is shown in Figure 2. This Figure also shows the gene flow of *Gmo^S* from the Korean peninsula into the Japanese Island except Hokkaido.

Poa-3^A is a predominant allele in the European

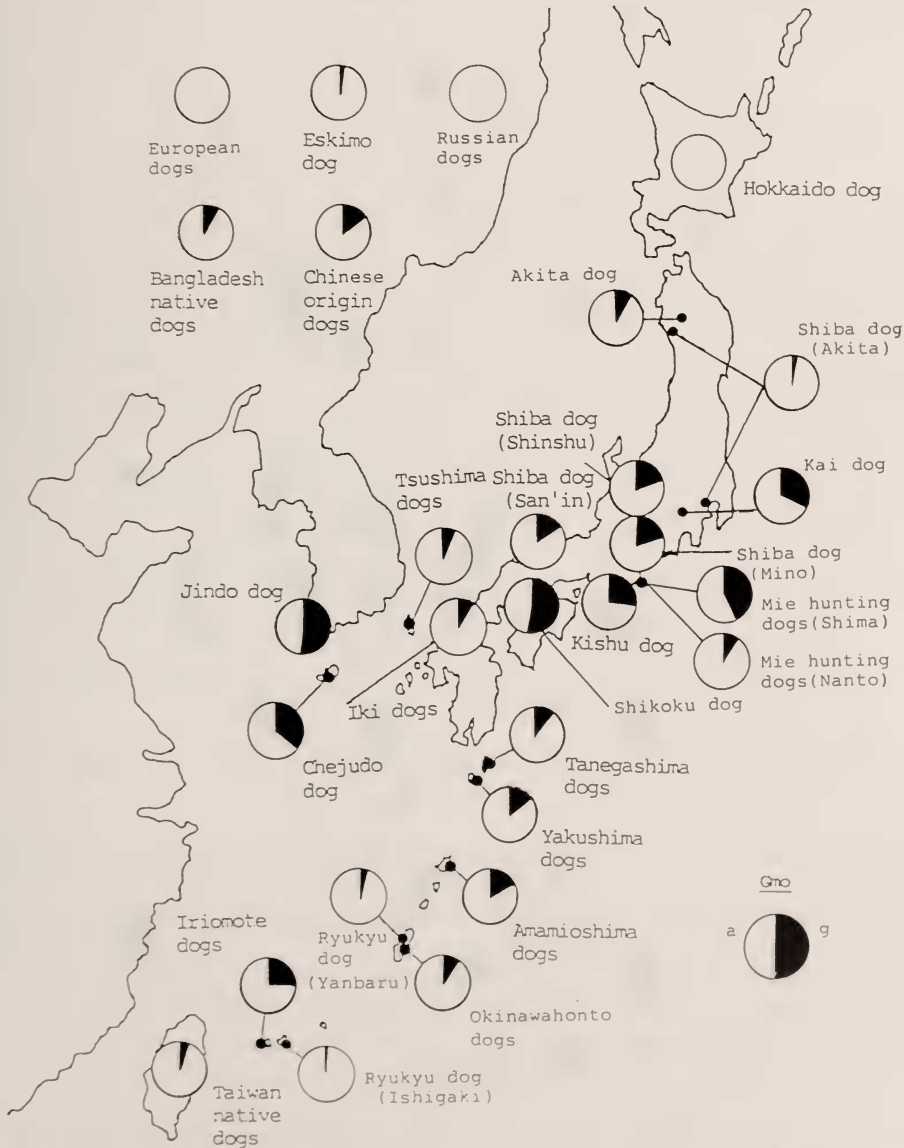


Fig. 2. Geographical distribution of dog erythrocyte glycolipid (*Gmo*) variants in Japan and its adjacent areas.

breeds, but the frequency of *Poa-3^B* is higher in the Asian breeds or populations than the European breeds. Distribution of *Poa-3* alleles among the Asian dog breeds or populations is shown in Figure 3. This Figure also shows the gene flow of *Poa-3^B* from the Korean peninsula into the Japanese islands. Similar tendencies were observed in the gene frequencies in *Poa*, *Alb*, *Tf*, *Es*, *Es-2*, *GPI*, and *Pac* polymorphisms among the dog breeds or populations examined in this study.

An apparent cline in the *Ptf* locus is observed in dog breeds or populations. *Ptf^A* predominates in the Eskimo, the Russian, the European, the Chinese origin and the Jindo (Korean) dogs, and is intermediate in most of the Japanese dogs in Honshu, but low in the Ryukyu, the Iriomote and the Hokkaido dogs in Japan, and the Bangladesh native dogs. Distribution of *Ptf* alleles among the Asian dog breeds populations is shown in Figure 4.

In order to summarize data of allele frequencies

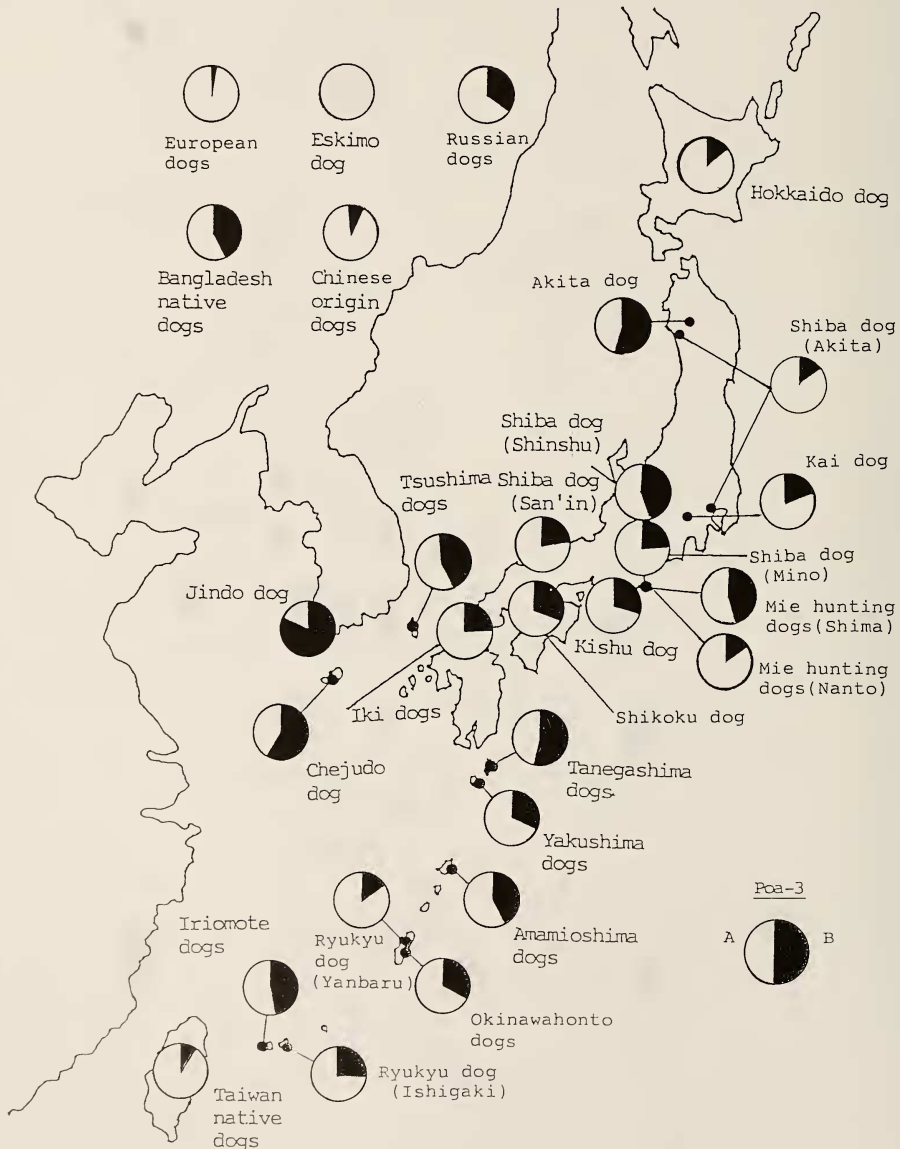


Fig. 3. Geographical distribution of dog plasma postalbumin-3 (*Poa-3*) variants in Japan and its adjacent areas.

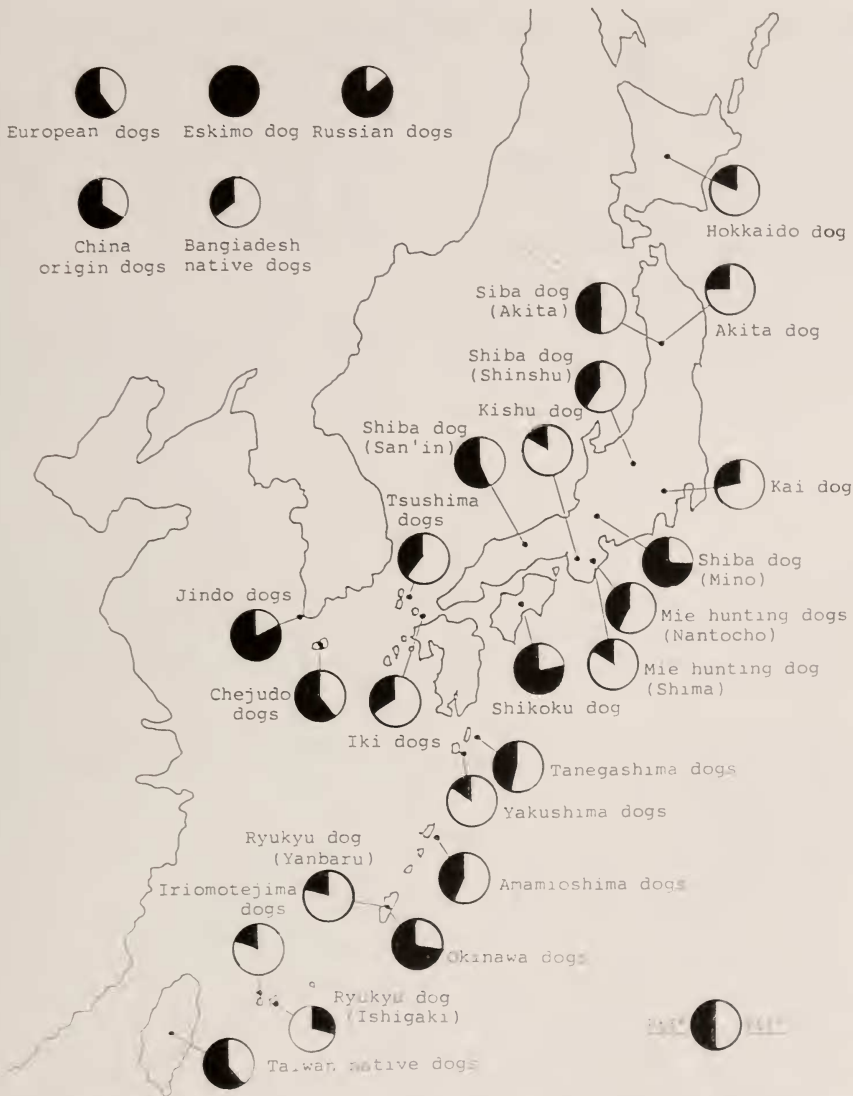


FIG. 4. Geographical distribution of dog plasma pretransferrin (*Ptf*) variants in Japan and its adjacent areas.

over variable loci, a principal component analysis (PCA) based on the variance-covariance matrix computed from the frequencies was conducted [Methodology references: 30, 31].

A scatter diagram of relative positions of the 46 dog breeds or populations plotted on the basis of the 1st and 2nd principal component scores is illustrated in Figure 5. These two components account for 44.9% of the total variance. This figure clearly show the existence of the two close relationships among some Japanese breeds or

populations of the Hokkaido, the Ryukyu (Yanbaru and Ishigaki), the Iriomote and the Yakushima dogs, and a close relationship among the Korean native breed (the Jindo) or population (the Chejudo), and some of Japanese native breeds and populations such as the San'in Shiba, the Akita, the Mie hunting dogs in Shima and the Tsushima dogs. Further, there is a close relationship among the Taiwan native dogs, the Chinese origin dogs (the Chin, the Pug and the Chow Chow), and the Mino-Shiba and the Shikoku. It can be postulated

1. Hokkaido dog
2. Akita dog
3. Kai dog
4. Kishu dog
5. Shiba dog (San'in)
6. Shiba dog (Shinshu)
7. Shiba dog (Mino)
8. Shiba dog (Akita)
9. Shikoku dog
10. Tanegashima dogs
11. Yakushima dogs
12. Amamioshima dogs
13. Okinawahonto dogs
14. Iriomote dogs
15. Mie hunting dogs (Sima)
16. Mie hunting dogs (Nantou)
17. Iki dogs
18. Tsushima dogs
19. Ryukyu dog (Yanbaru)
20. Ryukyu dog (Ishigaki)
21. Taiwan native dogs
22. Jindo dog
23. Chejudo dog
24. Bangladesh native dogs
25. Pointer
26. Maltese
27. Chin
28. Boxer
29. German Shepherd
30. Beagle
31. Shetland Sheepdog
32. Yorkshire Terrier
33. Dalmatian
34. English Setter
35. Cocker Spaniel
36. Pug
37. Chow Chow
38. Doberman Pinscher
39. Collie
40. Pomeranian
41. Dachshund
42. Poodle
43. Eskimo dog
44. Caucasian Sheepdog
45. Middle Asian Sheepdog
46. Laika

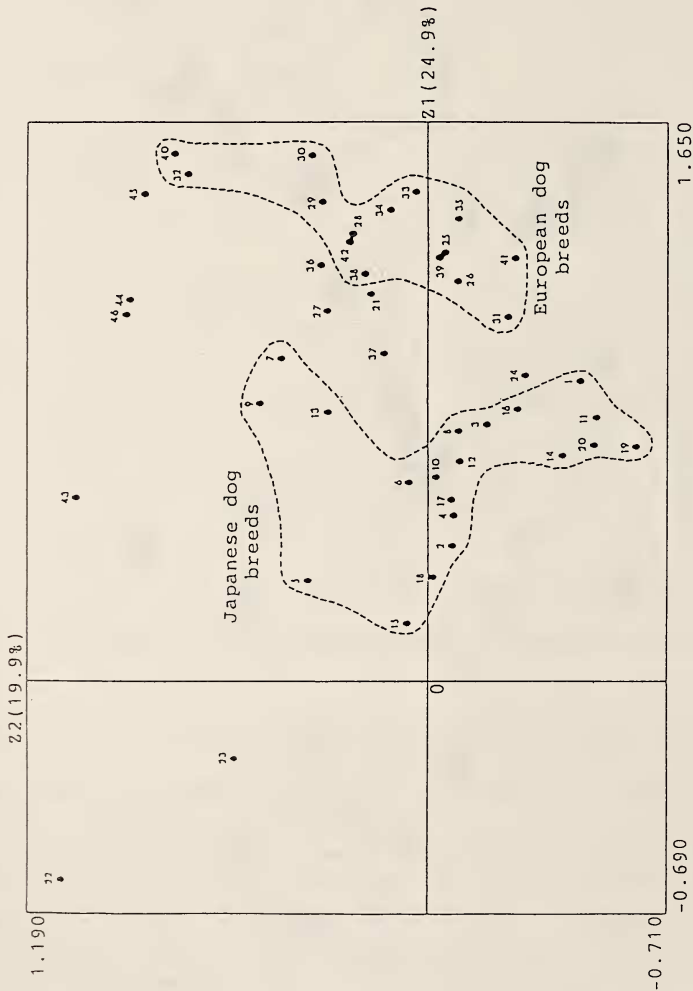


Fig. 5. Relative position of 46 dog breeds defined by the first (Z1) and the second (Z2) largest principal components of the distance matrix based on variance-covariance analysis of gene frequency at 16 polymorphic loci. Figures in parentheses represent the contribution to the total variations.

that there were at least two waves of the gene flow of dogs into Japan: the first was from southeast Asia through Ryukyu and/or Taiwan to the whole of the Japanese islands including Hokkaido, and the second was from the Korean peninsula to the Japanese main islands except Hokkaido.

It is interesting that a close relationship also was observed between the Hokkaido dog (the Ainu dog), which lives in the far-northern portion of Japan, and the Ryukyu dog, which lives in the far-southern portion of Japan. The gene constitution of the Hokkaido dog is different from most of the other Japanese dog breeds or populations except some dogs groups including the Ryukyu, the Iriomote, and the Yakushima dogs. Furthermore, a close relationship was observed between the gene constitution of the Chejudo dogs and some Japanese dog groups such as the San'in Shiba dog, the Tsushima dogs, and the Akita dog. The position of the Eskimo dog is far from all the other dogs, but some close relationship was observed to

the Russian dog breeds, i.e. the Laika and the Caucasian Sheepdog.

To simplify the data, dog breeds or populations used in the study were placed in seven groups: 1. Japanese native dogs (1, 556 dogs), 2. Korean native dogs (354 dogs), 3. Taiwan native dogs (144 dogs), 4. Bangladesh native dogs (60 dogs), 5. Chinese origin dogs (64 dogs), 6. European dogs (953 dogs), 7. Russian dogs (93 dogs) and 8. Eskimo dogs (20 dogs). The relative positions of the eight dog breed groups were defined by the first (Z1), second (Z2) and third (Z3) largest principal components of distance matrix based on variance-covariance analysis (Figure 6). These three components account for 87.2% of the total variance. In Figure 6, it is clear that the Japanese native dogs are located between a combined group of the Taiwan native dogs and the Chinese origin dogs, and a group of the Korean native dogs, while the position of the European dogs and the Russian dogs is also nearer, whereas those of the Bang-

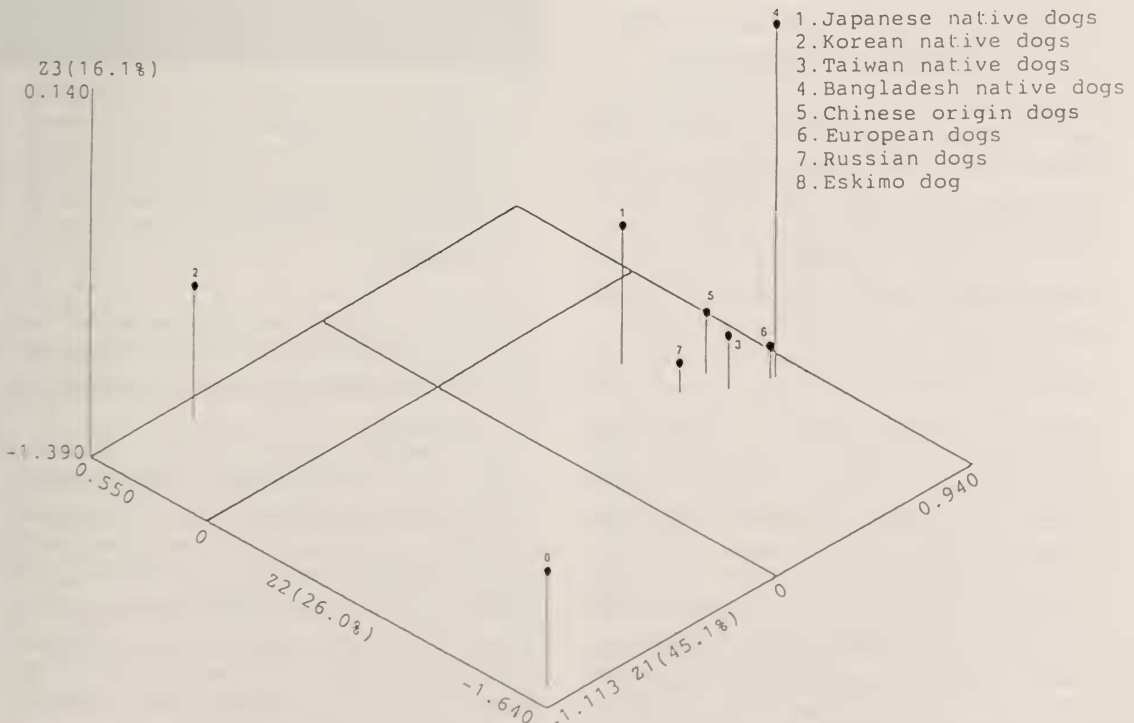


Fig. 6. Relative position of 8 dog breed groups defined by the first three (Z1-Z3) principal components of the distance matrix based on variance-covariance analysis of gene frequency at 16 polymorphic loci. Figures in parentheses represent the contribution to the total variation.

ladesh native dogs and of the Eskimo dog are farther from the Japanese native dogs.

From the results described above, it is postulated that the Hokkaido (Ainu) and the Ryukyu dog breeds are descended from an old type of the Japanese dog which was brought 10,000–12,000 years ago to Japan by the Jomonese who came from southeast Asia through Ryukyu islands. The other Japanese native breeds are descendants of the hybrid between the old type of the Japanese dogs and the Korean origin dogs which were brought 1,700–2,300 years ago by Yayoi migrants who came through the Korean peninsula.

The genetic distance between the Japanese native dogs and the Korean native dogs is farther than that between the Japanese native dogs and a combined group of the Taiwan native dogs and the Chinese origin dogs, suggesting that the numbers of an old types of the Japanese dog which was of southern origin, were larger than those of new comers from the Korean peninsula.

Cranial and Other External Studies on Dogs in Japan and Its Adjacent Areas

Archaeological evidence suggested that the cultuer of dog keeping, which was initiated 9,500 years ago at the earliest stage of the Jomon period, was brought into Japan from South China or somewhere else in southern parts of East Asia, and the Yayoi culture beginning 2,300 years ago, brought another group or groups of dogs into Japan through the Korean peninsula [32, 33].

A remarkable difference was observed in skull morphology between the dogs in the late Jomon period (ca. 3,500 years ago) and the dogs in the Middle age (13th Century) in Japan [34]. The former had flat or very shallow stops and the latter had deep stops (Figure 7). Dog skulls found in the Kuwanae remains in Oita Prefecture in Kyushu (aging ca. 2,000 years, the middle of the Yayoi perid) had deep stops [35] and showed a close affinity to dog skulls found in the Uenongigiseori-pohang remains in North Korea (aging 2,500–3,000 years). These skulls had deep stops [36], and were quite different from dog skulls found in many shell mounds in the Jomon period (2,500–10,000 years ago), where the skulls of the dog had flat or



FIG. 7. Skulls of dogs in ancient age in Japan. Top to down, a skull at Shuridai-shell mound in Chiba-shi, ca. 3,500 BP, the late Jomon period; at Hamaizumicho in Iwate prefecture, ca 3,500 BP, the late Jomon period; at Chibachihigashi Kamakura-shi, ca. 800 BP (AD 1,200); Ibid., Courtesy of Mr. Hiromasa Kaneko [34].

very shallow stops [37], indicating the introduction of a new type dog with deep stops into the Kyushu district of Japan from the Korean peninsula during the Yayoi period.

There are breed differences in the incidence of tongue spots. The incidence is about 30% in the Taiwan native dogs and 23.3% in the Ryukyu dog in Ishigaki, while is very low in the Jindo (1.9%) and the Chejudo (2.4%) dogs, and the values of Japanese native breeds varied between those of Taiwan and Korean dogs, i.e. the Hokkaido: 88.5%, the Akita: 1.4%, the Kai: 35.5%, the Kishu: 4.1%, the Shinshu Shiba: 0.7%, the San'in Shiba: 64.5%, the Mino Shiba: 19.1%, and the Shikoku: 21.8% [23, 25, 38].

It can be concluded that the main body of

Japanese native dogs was established by the cross-breeding between the older dogs brought from the southern area of East Asia and the newer dogs introduced from the northern part of the Asian Continent via the Korean peninsula.

Anthropology and Epidemiology of Japanese and Its Parasitic Organisms

Hanihara [39, 40, 41] showed the close affinities in cranial features between Ainu and the ancient Japanese in the Jomon period (Jomonese), and between the modern Japanese in Honshu, Korean and the ancient Japanese in the west and middle parts of Japan in the Yayoi period.

The genes controlling earwax and the blood protein polymorphisms of the modern Japanese people including Ainu and the people in adjacent areas in Asia, show similarities between Ainu and the people living in Southeast Asia, and between the Japanese living in Honshu and the Korean [42, 43].

The wild mice in the north Japan (Hokkaido and northern-half of Tohoku distinct) are close in the restriction of their mitochondrial DNA to those of Southeast Asia including Taiwan, and those of west, middle and southeast Japan (Honshu, except northern-half of Tohoku distinct, Shikoku and Kyushu) are close to those of Northeast Asia (Korea, Siberia and north China) [44]. The distribution pattern of mtDNA sequences is almost the same as in the case of Japanese dogs. Yonekawa and Moriwaki [44] concluded that the wild mice from Southeast Asia distributed first in Japan, and then another variety of mice came from Northeast Asia in the company of new human groups who migrated through the Korean peninsula, and settled in the west, middle and southeast of Japan.

Hepatitis B virus, coexisting with human beings from the ancient age, has been transmitted from hepatitis Be antigen positive mothers to newborn babies (cell-mediated infection). More than 5% of population in the world are estimated as hepatitis B virus carriers, and "adr" subtype of the virus is predominant in the northeast of Asia, while "adw" subtype is predominant in South Asia including Taiwan and Ryukyu islands [45]. It is interesting that "adr" subtype is predominant in west, middle

and southeast Japan, while "adw" subtype is predominant in northern Japan including Tohoku and Hokkaido distincts, suggesting that "adw" carriers first occupied Japan, and new comers from the Korean peninsula brought "adr" subtype of the virus [45]. Adult T-cell leukemia (ATL) virus is also transmitted from ATL-associated antigen (ATLA) positive mothers to new born babies in human beings [46]. Incidence of ATL virus carriers is relatively high in Ryukyu islands (33.9%) and Ainu in Hokkaido (45.2%), moderately high in Japanese in Kyushu (7.8%), very low in other Japanese in Honshu (0.7%), Hokkaido (1.1%) and Shikoku (0.5%), and null among the Koreans and Chinese, suggesting that the aborigines were carriers of the virus, whereas the newcomers were not carriers of the virus [46, 47].

All data described above suggest that the Japanese population consists of at least two elements, one of which came from Southeast Asia and the other came from Northeast Asia.

Conclusions

The genetic relationships of 46 Asian and European dog breeds or populations were studied by using the protein polymorphisms detected by electrophoretic and chemical analysis. Blood samples taken from 3,632 dogs including 11 Japanese, one Korean, three of Chinese origin, Eskimo and 15 European breeds, and eight Japanese, one Korean, one Taiwanese and one Bangladesh populations. Protein polymorphisms were observed in 16 loci: *Es*, *Lap*, *Akp*, *Hb*, *Es-2*, *Es-3*, *Pac*, *GPI*, *To*, *Gmo*, *Pa-1*, *Alb*, *Poa*, *Poa-3*, *Ptf* and *Tf*. A scatter diagram of the 46 breeds or populations on the basis of the principal component analysis elucidates the existence of three close relationships among the Ryukyu dog, the Iriomote dogs, the Yakushima dogs and the Hokkaido dogs, and among the Korean native breed (the Jindo) and a population (the Chejudo), the Taiwan native dogs, the Chinese origin breeds, and some of the Japanese native breeds or populations in Honshu such as the San'in Shiba, the Mic hunting dog in Shima, the Tsushima and the Akita dogs. There were two gene flows in dogs into Japan. The first was from Southeast Asia through the Ryukyu

islands to all the Japan islands. The second was from the Korean peninsula to the Japanese islands except Hokkaido and Ryukyu islands. It is assumed that the Hokkaido (Ainu) dog and the Ryukyu dog are descendants of an old type of the Japanese dogs which were brought to Japan 10,000–12,000 years ago by the Jomonese who came from Southeast Asia, and that most of the other Japanese native breeds are descendants of the hybrid between the old type of Japanese dogs and the Korean origin dogs, which were brought 1,700–2,300 years ago by the Yayoi migrants who came through the Korean peninsula. All the data obtained in the anthropology on Japanese and Asian people and the epidemiology of them by their parasitic viruses, together with our data on dogs, support the view of the “dual structure model” for the population history of the Japanese.

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